I.9 TRENDS AND POTENTIAL OF EGYPTIAN WHEAT GERMPLASM FOR ALLELOPATHIC ACTIVITY AGAINST WEEDS

EL-MAGHRABY, M.A.[1], Y.M. MABROUK[2] and MAHA A. GADALLAH[1]

1. *Wheat Res. Dep., Field Crops Res. Inst., ARC, Giza, Egypt.*
2. *Dep. of Genetics, Fac. Of Agric., Alex. Univ., Egypt.*

Abstract

The major goals of the present study were to evaluate the Egyptian wheat cultivars for their yielding and competitive ability against weeds (Avena fatua L) under local conditions and to study wheat allelopathic activity to select superior cultivars with strong allelopathic activity to be used as a source in plant breeding. Thirty-six Egyptian wheat cultivars were evaluated at Nubaria Res. Stn. Results showed highly significant variation among cultivars with respect to different characteristics. Results also showed that Sakha 61, Gemmeiza 10, Sakha 94, Gemmeiza 7, Giza 168 and Giza 155 were more productive, while Tosson, Giza 160, Giza 163, Gemmeiza 1 and Giza 139 produced lower yields under herbicide application. Under stress condition (non-herbicide application), Sakha 92, Sids 1, Sids 4 and Gemmeiza 9 were more productive, while Giza 139, Giza 160, Giza 162, Giza 163 and Sakha 93 showed lower yields. Most of high-yielding cultivars under normal or stress condition showed high number of spikes m^{-2}, which indicated the importance of this trait to increase grain yield. Cultivars differed significantly in grain yield losses according to the presence of different number of Avena fatua weed m^{-2}. Sakha 61 produced the highest reduction in grain yield (77%), while Giza 170, Sids 6 and Tosson showed lower reduction in grain yield in the presence of 20, 10 and 5 Avena fatua weed m^{-2}. Results also showed significant differences in allelopathic activity against spring wild oats (Avena fatua L.) as monocot weed species. Among these cultivars, six cultivars were strongly allelopathic giving a smaller root length of Avena fatua such as Giza 160, Giza 170, Giza 168, Gemmeiza 5, Giza 157 and Sakha 8, while most of the other cultivars recorded intermediate values of root length. In relation to Potential and Specific Allelopathic Activity (PAA, SPAA), a normal distribution among cultivars was observed. Some cultivars had strong PAA effect showing highest percentage such as Sakha 8, Giza 157, Gemmeiza 5, Giza 168, Giza 170 and Giza 160, while some other cultivars like Gemmeiza 7, Gemmeiza 3, Sakha 94, Sids 9 showed lower percentages. The same trend was observed for SPAA. These findings indicate that the competitive trait and allelopathic trait may not be genetically linked and that the breeding for wheat cultivars with enhanced competitiveness coupled with allelopathy may be accomplished for weed suppression.

Keywords: Triticum aestivum L., Avena fatua L., Sinapis arvensis L., allelopathy

INTRODUCTION

Wheat (*Triticum aestivum* L.), as one of the major crops in the world has been considered the first strategic food crop in Egypt. Therefore, increasing wheat production becomes an important national goal to reduce wheat imports, and provide enough food to meet increasing domestic demand. In wheat breeding programs, the choice of parents is the most important step in the development of adapted cultivars to biotic and abiotic stresses.

Weeds are one of the most important biotic stresses and the major constraints to wheat production. Wheat growers have become increasingly reliant on synthetic herbicides for weed control in their farming systems. However, the extensive use of herbicides has resulted in the rapid development of herbicide resistance in weeds. The ineffectiveness of herbicides on resistant weed species and environmental imperatives has prompted the search for non-herbicidal innovations to manage weed populations (Wu *et. al.,* 1999). Wheat can compete well with weeds, but strong weed competition reduces yield. In contrast to the control of pests and diseases, very little breeding has been carried out to improve weed suppressive ability. Reasons for this are the availability of effective herbicides but also a poor understanding of competitive ability, its mechanisms, components and relative importance.

Allelopathy in wheat refers to the fact that wheat can chemically affect the growth of other plants by secondary metabolites exudation into the surrounding environment (Zhang *et. al.,* 2004). Allelopathy may also affect the growth of wheat plants themselves, a phenomenon known as the auto-toxic effect (Wu *et. al.,* 2001). Wheat cultivars differed significantly in their allelopathic effects on the establishment of the following wheat crop (Guenz *et. al.,* 1967; Kimber, 1967). Weed suppression by crop allelopathy during the early establishment period could reduce the need for commercial herbicides to early season application, with late season weed control provided by the heightened advantages of crop competitiveness.

Thirty-eight wheat cultivars (*Triticum aestivum* L.) and one durum wheat (*Triticum durum* Desf.) were used to evaluate the differential allelopathic potential against annual ryegrass (*Lolium rigidum* Gaud.) by an extract bioassay (*Wu et. al.,* 1999). Results showed that both germination and root growth of ryegrass were significantly inhibited by the aqueous shoot extracts of wheat cultivars, the degree of inhibition differed significantly among cultivars. Recently, 813 spring wheat cultivars were evaluated for their allelopathic potential (Bertholdsson, 2007) against annual ryegrass (*Lolium prenne* L.) using ECAM. Results showed that there is a positive trend for Potential Allelopathic Activity (PAA) in new released cultivars and the frequency distribution of PAA follows a normal distribution pattern. More recently, seven durum wheat cultivars resulted from conventional breeding program in Egypt were evaluated for allelopathy activity against mono-and di-cot weed species using bio-assay in seedling stage (El-Maghraby *et. al.,* 2008). Wheat Allelopathic activity was normally distributed within the collection, indicating that the allelopathy trait is quantitatively inherited. Significant differences in weed root length, potential and specific potential allelopathic activity, wheat competitive response, and weed competitive effect were found in this collection. However, there is a little information on genetic variation of allelopathic potentials for designing allelopathic breeding program with extreme cultivars for allelopathic effects (Olofsdotter *et. al.,* 2002). In the present investigation, Egyptian wheat cultivars were tested for their yielding ability with weed competition under Nubaria conditions and crosses among some of these cultivars were conducted. The main goal of the present research work was evaluating some Egyptian wheat cultivars for their yielding ability and their competitive ability against wild oat weed (*Avena fatua* L.) under local conditions. Studying of wheat allelopathic activity for Egyptian wheat germplasm to select superior cultivars with strongly allelopathic activity that can be used in the traditional wheat breeding program was another target for this work.

MATERIALS AND METHODS

Plant Material

The studied wheat (*Triticum aestivum* L.) genotypes were selected from the germplasm bank of Wheat Research Program, Agricultural Research Center, Egypt which represents a wide genetic background. Moreover, the studied genotypes included 36 Egyptian wheat cultivars. Name, pedigree and origin of these genotypes are presented in Table 1. The present investigation was carried out at Nubaria Agriculture Research Station, Agriculture Research Center for two seasons (2007/2008 and 2008/2009).

Methodology

Field evaluation of the 36 Egyptian wheat cultivars

The collected Egyptian wheat cultivars were evaluated in two seasons (2007/2008 and 2008/2009) and was designed in a randomized complete block design with three replications. The size of each plot was 10.5 m^2 (3.5m x 3.0m) and seeds were drilled by hand. The dry method of planting was used. Each season has two experiments; the first experiment was treated with herbicide application for dicot and monocot weeds, while the second experiment was conducted without herbicide application of monocot weeds, the dicot weeds were suppressed by herbicide application.

Bioassay protocol

Sterilization and Pre-germination

Wheat seeds were surface-sterilized by soaking the seeds in 70% ethanol for 2.5 min, followed by 4 rinses in distilled water. Seeds were then soaked in 2.5% sodium hypochlorite solution for 15 minutes followed by 5 rinses in sterilized distilled water. The seeds for weeds were sterilized by soaking in 2.5% sodium hypochlorite solution for 10 minutes and followed by rinsing in distilled water for another 10 minutes. Wheat and weed sterilized seeds were incubated in darkness on the filter paper at 22°C for pre-germination for three days.

ECAM (Wu *et. al.*, 2000)

In this technique, plastic tissue culture vials were filled with 40 ml 0.3% water agar (no nutrients) and autoclaved. Ten pre-germinated wheat seeds were planted circular along the vials wall with ten pre-germinated weed seedlings, planted in the center of the vial. The vials were covered by lid and placed in a growth chamber with a light/dark cycle of 16/8 hr, at a temperature of 20°C and inflorescent light. After seven days, a simple staining procedure by Methyl Violet Staining for 24 hr was applied to roots to obtain better result. The root length (mm) of weed species was measured using an image analyzer (DIAS, Delta-T Devices, Cambridge, (England). Vials with only weed were used as control. The wheat roots were dried at 80°C for 48 hr and dry weight was measured.

Data recorded

The field data were recorded as grain yield per plot (kg $Fed.^{-1}$) for all cultivars and number of spikes per m^2 for all cultivars. The Bio-assay data were recorded as weed root length (mm), wheat root length (mm), and wheat root biomass (fresh and dry weight).

Calculation and Statistical analysis

Potential Allelopathic Activity (PAA) (Bertholdsson, 2007) was calculated according to PAA= (1- A1/A2)*100 with A1= weed root length in presence of wheat and A2=weed root length without wheat. Based on PAA, Specific Potential Allelopathic Activity (SPAA) was calculated as SPAA=PAA/root dry weight. Competitive Response (CR) was calculated according to CR= {1-(1/A1-A2)} with A1= root biomass of wheat (control), A2=root biomass of wheat with weed. The experiment was arranged in a randomized complete block design with four replicates. The analysis of variance was conducted using SAS program (9.01 ver.). Means were separated using LSD test and statistical significance was evaluated at $P \leq 0.05$.

Statistical Analysis

Data were subjected to proper statistical analysis of variance according to Snedecore and Cochran (1967). The combined analysis was conducted when the homogeneity test between error variance was detected according to Cochran and Cox (1957). For comparison between means, Duncan's multiple range test was used (Duncan, 1955).

Table 1. Name and pedigree of the studied bread wheat genotypes.

No	Cultivar	Pedigree
1	Sakha 8	Cno 67//SN64/KLRE/3/8156 PK 3418-6S-0S-0S
2	Sakha 61	Inia/RL 4220//7C/Yr "S" CM 15430-2S-55-0S-0S
3	Sakha 69	Inia/RL 4220//7C/Yr "S" CM 15430-2S-55-0S-0S
4	Sakha 92	Napo 63/Inia 66//Wern "S" S.1551-1S-1S-1S-0S
5	Sakha 93	Sakha 92/TR 810328 S 8871-1S-2S-1S-0S
6	Sakha 94	Opata/Rayon//Kauz.
7	Giza 139	Hindi 90/Kenya B256
8	Giza 144	Regent/ 2* Giza 139
9	Giza 155	Regent/2*Giza139//Mida Cadet2*Hindi 62
10	Giza 157	Giza 155//Pit62/LR64/3/Tzpp/Knott
11	Giza 160	Chenab / Giza 155
12	Giza 162	Vcm//Cno 67/7C/3/Kal/Bb CM8399-D-4M-3Y-1M-1Y-1M-0Y
13	Giza 163	T. aestivum / Bon//Cno/7C CM33009-F-15M-4Y-2M-1M-1M-1Y-0M
14	Giza 164	KVZ/Buba"S"//Kal/Bb CM33027-F-15M-500Y
15	Giza 167	AuUP301//G11/SX/Pew"S"/4/Mal"S"/May"S"//Pew"S"CM67245-C-1M-2Y-1M-7Y-1M-0Y
16	Giza 168	MIL/BUC//Seri CM93046-8M-0Y-0M-2Y-0B
17	Giza 170	
18	Gemmiza 1	Maya 74/On//1160.147/3/Bb/1991 Gall/4/Chat"S" CM58924-1GM-OGM
19	Gemmiza 3	Bb/7C*2//Y50/Kal*3//Sakha8/4/Prv/WW/5/3/Bg"S"// On CGM. 4024-1GM-13-GM-2GM-0GM
20	Gemmiza 5	Vee"S"/SWM 6525 CGM 4017-1GM-6GM-3GM-0GM
21	Gemmiza 7	CMH74 A. 630/5x//Seri 82/3/Agent CGM 4611-2GM-3GM-1GM-0GM
22	Gemmiza 9	Ald"S"/Huac"S"//CMH74A.630/5x CGM4583-5GM-1GM-0GM
23	Gemmiza10	Maya 74 "S"/On//1160-147/3/Bb/4/Chat"S" /5/ctow.
24	Sids 1	HD2172/Pavon "S"//1158.57/Maya 74"S" Sd46-4Sd-2Sd-1Sd-0Sd
25	Sids 3	Sakha 69/Giza 155
26	Sids 4	Maya's'/Mon's'//CMH74A.592/3/Giza 157*2
27	Sids 6	Maya's'/Mon's'//CMH74A.592/3/Sakha 8*2
28	Sids 7	Maya's'/Mon's'//CMH74A.592/3/Sakha 8*2
29	Sids 8	Maya's'/Mon's'//CMH74A.592/3/Sakha 8*2
30	Sids 9	Maya's'/Mon's'/4/CMH72.428/Mrc//Jup/3/CMH 74A.582/5/Giza 157*2
31	Sids 12	BUC//7C/ALD/5/MAYA74/ON//1160.147/3/BB/GLL/4/CHAT"S"/6/MAYA/VUL//CMH74A.630/4*SX SD7096-4SD-1SD-1SD-0SD
32	Sahel 1	N.S.732/Pim/Vee"S"
33	Shandaweel 1	
34	Chenab 70	C271/W1 (E)//Son 64
35	Mexibac 65	Penjamo / GB55/118156
36	Tosson	Selected Local Variety

RESULTS AND DISCUSSION

In wheat breeding program, the choice of parents is the most important step in the development of adapted cultivar to biotic and abiotic stresses. During selection of desirable plants from the segregating population, the plant breeder is faced with the following problems; (i) he has to screen a large segregating population for a desirable trait e.g., weed competition, (ii) he has to wait for advanced generations (F5, F6) to exercise selection for quantitative traits, for which selection in early generation is not effective; (iii) it becomes very difficult, if not impossible to screen the population for a desired trait when the trait is influenced by environment; (iv) contrasting forms are often not distinguishable at the seedling stage, making it necessary to grow population up to the adult stage. In view of these difficulties, availability of tightly linked molecular markers for a trait will facilitate plant breeding by saving time and expenses

Evaluation of the Egyptian wheat cultivars (Field Experiment)

Separate analysis of variance was carried out for yield and number of spikes per m2 in each season at Nubaria (Table 2). The analysis of variance indicated highly significant variation among cultivars which revealed differences for all studied characteristics in this experiment. The table showed that there is significant effect for weed treatment and the results indicated that treatment mean squares for the studied traits were highly significant. Mean squares for interaction between treatments and cultivars were found to be significant and test of homogeneity of the error variance was insignificant.

Table 3 represents the mean and combined data over the two seasons of the 36 Egyptian wheat cultivars for yield and number of spikes per m2. Data showed that cultivars, Sakha 61, Gemmiza 10, Sakha 94, Gemmiza 7 and Giza 155 were the most productive (22.9, 16.4, 16.2, 16.1 and 15.0 Ardab fed.$^{-1}$, respectively), while cultivars Tosson, Giza 160, Giza 163, Sids 12, Gemmiza 1 and Giza 139 resulted in poor yielding (6.4, 7.3, 7.5, 8.7, 8.9 and 9.2 Ardab fed.-1, Respectively). The other cultivars showed different behavior and revealed variability between them under recommended conditions (herbicide application). On the other hand, under stress conditions (competitive with wild oat weed-non herbicide application) Sakha 92, Sids 1, Sids 4 and Gemmiza 9 were most productive (10.5, 9.8, 9.7, 9.2 and 9.2 Ardab fed.-1, respectively), while Giza 139, Giza 160, Giza 162, Giza 163 and Sakha 93 showed poor yielding (4.6, 4.6, 4.9, 4.9 and 5.0 Ardab fed.-1, respectively). The other cultivars showed different behavior and revealed variability between them under stress conditions (non-herbicide application).

Some Egyptian cultivars showed high reduction in grain yield under stress condition compared to recommended condition such as Sakha 61, Gemmiza 7, Sakha 93, Sakha 8 and Giza 157 (77, 66, 62, 59 and 59%, respectively), while other cultivars showed lowest reduction in grain yield under stress condition compared to recommended condition such as Giza 170, Sids 1, Tosson, Sids 6, Sakha 92 and Sids 9 (0.09, 0.12, 0.12, 0.13, 0.22 and 0.22%, respectively). Figure (1) showed the comparison in grain yield among all Egyptian cultivars under recommended (herbicide application for wild oat) and stress condition (non-herbicide application for wild oat). The differences between cultivars in grain yield regarding competitive effect of wild oat compared to recommended condition are illustrated in Figure (2).

The average number of spikes per m2 ranged from 256 for Giza 160, which produced the least number of spikes per m2 to 511 for Sakha 94, which showed the highest number of spikes per m2. Table 3 showed that some cultivars occupied best ranking for number of spikes per m2 such as Sakha 94, Giza 164, Giza 144, Gemmiza 5 and Sakha 8 (517, 511, 493, 484 and 479, respectively), while Giza 160, Giza 163, Sids 6, Sakha 61 and Sids 3 showed lowest number of spikes per m2 (256, 271, 288, 312 and 312, respectively) under recommended condition. Regarding stress condition, results revealed that number of spikes per m2 ranged from 360 for Giza 168 to 144 for Giza 144 as lowest cultivar. Cultivars Giza 168, Giza 164, Sakha 92, Sakha 8 and Giza 170 occupied best ranking for this trait (360, 352, 351, 335 and 311, respectively), while Giza 144, Chenab 70, Tosson, Sahel 1 and Giza 163 showed lowest ranking (155, 157, 158, 173, 181, respectively). The table showed the comparison between number of spikes per m2 under recommended condition and stress conditions, Giza 144 showed the highest reduction in this trait (68%), while Giza 160 showed the lowest reduction (0.03%). However, the rest of cultivars varied for number of spikes per m2 under both conditions.

Losses in grain yield due to wild oat competition with different wheat cultivars are shown in Table 4. Results differed significantly for losses in grain yield according to the presence of different numbers of wild oat weed per m2. In Case of presence of 20 wild oat weed per m2, Sakha 61 was the highest reduced cultivar for grain yield (77%). On the other hand, Giza 170, Sids 6 and Tosson cultivars showed the lowest reduction in grain yield due to this number of weeds per m2 (0.09, 0.12 and 0.12%, respectively). The same trend of reduction for grain yield was observed in presence of 10 and 5 wild oat weed per m2 as shown in Table 4. All Egyptian wheat cultivars except Sakha 61, Giza 170, Sids 6 and Tosson varied for their losses in grain yield with 5, 10 and 20 wild oat weed per m2.

Analysis of variance indicated high significant variation among cultivars, which revealed differences for all studied characteristics in this experiment. The effect of change in some other agronomic traits on yield components is taken into consideration because yield is usually the result of multitude of factors and their favorable and unfavorable interaction at different growth duration of the plant. The effect of interaction between weed treatment and wheat cultivars were significant for all the traits under study, this result may be due to the differences in response of cultivars for Avena fatua root suppression under Nubaria conditions. The results showed that there is significant effect for weed treatment and the results indicated that treatments mean square for the studied traits were highly significant.

Most of high-yielding cultivars under normal or stress condition showed high number of spikes per m2 , which indicated the importance of this trait to increase grain yield and as a main component for grain yield (Gomaa, 1999; Larbi *et. al.,* 2000; Garc *et. al.,* 2003 and El-Borhamy, 2008). These findings indicate that the modern cultivars have the potentiality to maximize their yield under both normal and with weed competitiveness in addition to some old cultivars such as Sakha 61. These results confirm the role of the wheat breeding program in releasing new cultivars with high productivity and ability to compete with weeds. These results are in accordance with those obtained by El-Maghraby (2008) and Solomon et al. (2003).

Table 2. Mean square values of analysis of variance among genotypes for grain yield and number of spikes m^{-2} (mean of two years).

S.O.V	d.f.	M.S	
		Grain Yield	No. of spikes m^{-2}
Replications	3	1034.61	45.44
Treatments	1	10431028.12 **	1410080.22 **
Error $_a$	3	1002.2	485.44
Cultivars	35	141228.44 **	29581.16 **
Treatment x Cultivar	35	102093.12 **	12667.34 **
Error $_b$	210	2352.9	589.3

** Significant at $P \leq 0.01$ level of probability.

Table 3. Means and reduction of Grain Yield (g) and number of spikes m-2 in presence (non-herbicide application) and absence (with herbicide application) of wild oat weed.

Cultivar	Grain yield			No. spikes m^{-2}		
	Non-herbicide application Ardab $fed.^{-1}$	With herbicide application Ardab $fed.^{-1}$	Reduction (%)	*Non*	*With*	Reduction (%)
Sakha 8	5.4	13.3	*0.59*^{d}	*335*^{d}	*479*^{e}	0.30
Sakha 61	5.2	*22.9*^{a}	*0.77*^{a}	239	*312*^{d}	0.23
Sakha 69	7.8	13.3	0.41	283	428	0.33
Sakha 92	*10.5*^{a}	13.4	*0.22*^{d}	*352*^{c}	393	0.10
Sakha 93	*5.0*^{c}	13.4	*0.62*^{c}	251	467	0.46
Sakha 94	*9.2*^{d}	*16.2*^{c}	0.43	279	*517*^{a}	0.46
Giza 139	*4.6*^{a}	9.2^{f}	0.49	208	343	0.39
Giza 144	7.0	12.0	0.42	*155*^{a}	*493*^{c}	*0.68*
Giza 155	6.6	*15.0*^{e}	0.55	232	411	0.43
Giza 157	4.9	12.0	*0.59*	219	354	0.38
Giza 160	*4.6*^{a}	*7.3*^{b}	0.36	246	*256*^{a}	*0.03*
Giza 162	*4.9*^{b}	11.2	0.56	300	420	0.28
Giza 163	*4.9*	*7.5*^{c}	0.34	*181*^{e}	*271*^{b}	0.33
Giza 164	6.8	14.3	0.52	*351*^{b}	*511*^{b}	0.31
Giza 167	5.6	10.5	0.46	243	373	0.34
Giza 168	7.6	12.0	0.36	*360*^{a}	467	0.22
Giza 170	8.0	*8.9*^{e}	*0.09*^{a}	*311*^{e}	380	0.18
Gemmiza 1	6.6	*8.9*	0.25	289	407	0.28
Gemmiza 3	8.6	12.4	0.30	257	457	0.43
Gemmiza 5	6.9	11.3	0.38	228	*484*^{d}	0.52
Gemmiza 7	5.4	*16.1*^{d}	*0.66*^{b}	231	371	0.37
Gemmiza 9	*9.2*^{d}	15.5	0.40	247	407	0.39
Gemmiza10	8.2	*16.4*^{b}	0.49	271	432	0.37
Sids 1	*9.8*^{b}	11.2	*0.12*^{b}	264	399	0.33
Sids 3	7.1	10.6	0.32	247	*312*^{d}	0.20
Sids 4	*9.7*^{c}	14.5	0.32	236	405	0.41
Sids 6	8.5	*9.8*	*0.13*^{c}	217	*288*^{c}	0.24
Sids 7	5.7	12.6	0.54	197	371	0.46
Sids 8	6.8	14.0	0.51	279	349	0.20
Sids 9	8.0	10.3	*0.22*	276	329	0.16
Sids 12	7.0	*8.7*^{d}	0.20	207	359	0.42
Sahel 1	5.4	10.1	0.46	*173*^{d}	393	0.55
Shandaweel	7.5	12.2	0.38	245	380	0.35
Chenab	8.2	11.3	0.27	*157*^{b}	315	0.50
Mexibac 65	6.1	13.3	0.53	213	331	0.35
Tosson	5.7	6.4^{a}	0.12	158^{c}	294	0.46

- Harvested area = 2 m^2
- Ardab= 150 kg seed weight

Table 4. Reduction in grain yield caused by different number of wild oat weed.

Cultivar	Grain Yield		
	Avena fatua (*5 plants* m^{-2})	*Avena fatua* (*10 plants* m^{-2})	*Avena fatua* (*20 plants* m^{-2})
Sakha 8	0.13	0.22	0.59
Sakha 61	0.17	0.30	0.77
Sakha 69	0.09	0.16	0.41
Sakha 92	0.05	0.11	0.22
Sakha 93	0.14	0.25	0.62
Sakha 94	0.09	0.17	0.43
Giza 139	0.11	0.20	0.49
Giza 144	0.09	0.20	0.42
Giza 155	0.12	0.27	0.55
Giza 157	0.13	0.24	0.59
Giza 160	0.08	0.18	0.36
Giza 162	0.12	0.24	0.56
Giza 163	0.07	0.14	0.34
Giza 164	0.11	0.23	0.52
Giza 167	0.10	0.21	0.46
Giza 168	0.08	0.14	0.36
Giza 170	0.02	0.06	0.09
Gemmiza 1	0.05	0.12	0.25
Gemmiza 3	0.06	0.14	0.30
Gemmiza 5	0.08	0.15	0.38
Gemmiza 7	0.15	0.34	0.66
Gemmiza 9	0.09	0.16	0.40
Gemmiza10	0.11	0.20	0.49
Sids 1	0.02	0.05	0.12
Sids 3	0.07	0.16	0.32
Sids 4	0.07	0.13	0.32
Sids 6	0.03	0.05	0.13
Sids 7	0.12	0.20	0.54
Sids 8	0.11	0.20	0.51
Sids 9	0.05	0.08	0.22
Sids 12	0.04	0.07	0.20
Sahel 1	0.10	0.19	0.46
Shandwell 1	0.08	0.15	0.38
Chenab 70	0.06	0.10	0.27
Mexibac 65	0.12	0.20	0.53
Tosson	0.02	0.06	0.12

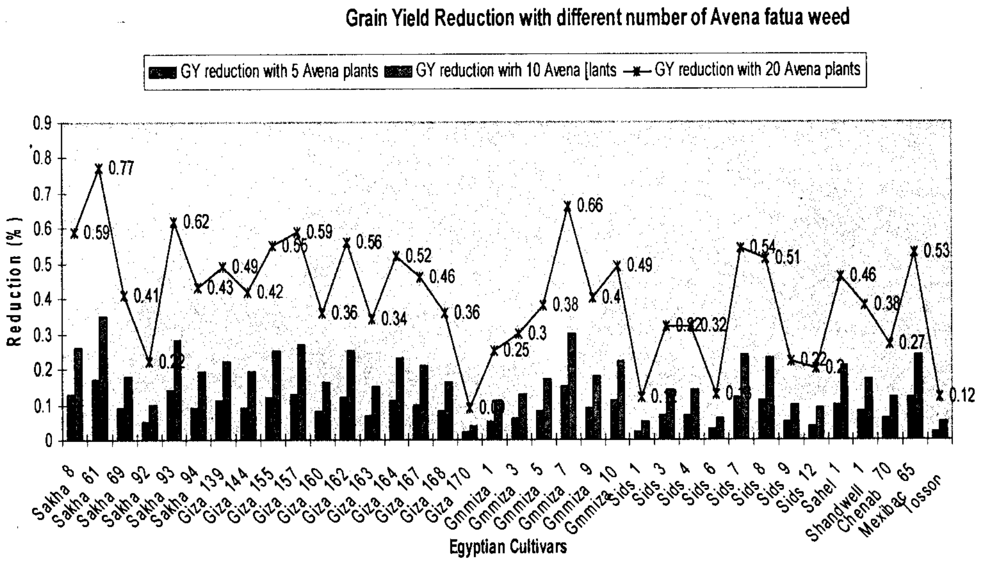

Fig. 1. Reduction in grain yield in the presence of 5, 10 and 20 wild oat weed per m^2 for Egyptian wheat cultivars.

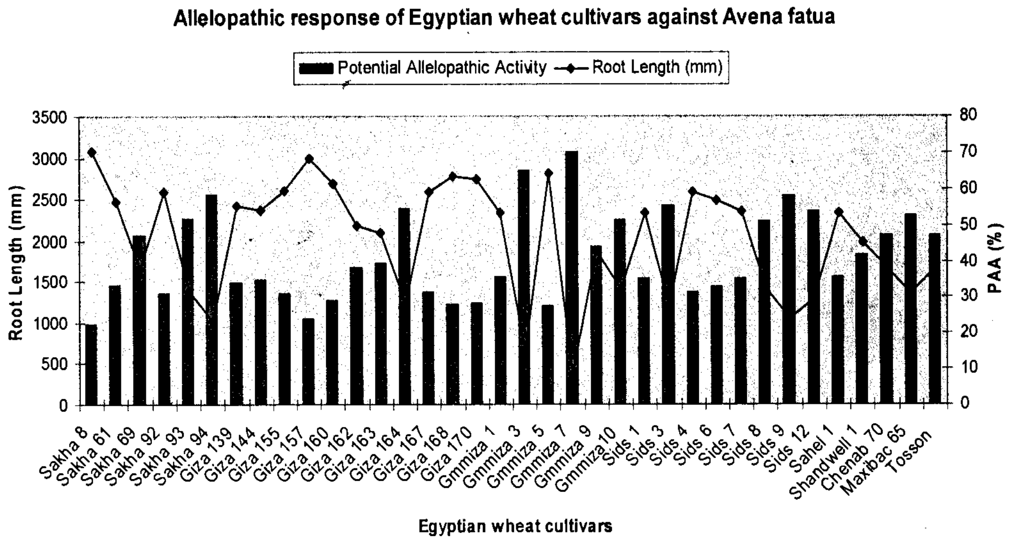

Fig. 2. Allelopathic response of Egyptian wheat cultivars against wild oat.

Bio-assay protocol (Lab. Experiment)

Genetic variation in Egyptian wheat cultivars

Analysis of variance of the 36 Egyptian wheat cultivars showed that the cultivars differed significantly in their allelopathic activities for all studied traits with wild oat (Table 8), thereby providing a sufficient gene pool for the development of allelopathic wheat cultivars in order to suppress weed. A normal distribution of wheat allelopathic activity was found in this collection of Egyptian wheat cultivars with Avena species indicating that wheat allelopathic activity is a quantitative trait (Stephan Machado, 2007 and Belz RG *et. al.,* 2004), (Fig. 2).

Wheat allelopathy effects on the root growth of Avena species

Out of the 36 Egyptian wheat cultivars as shown in Table 7, six cultivars had strong allelopathic effect giving the smallest root length, some other cultivars were weak allelopthic giving the highest root length, and the rest of wheat cultivars showed an intermediate root length values. In comparison with control (wild oat) of 3330.1 mm root length, six cultivars were strongly allelopathic giving the smallest root length of wild oat such as Giza 160, Giza 170, Giza 168, Gemmiza 5, Giza 157 and Sakha 8 (1275.9, 1242.6, 1221.2, 1197.0, 1046.9 and 988.2 mm, respectively). Five cultivars were weak and showed the highest values for Avena root length such as Gemmiza 7, Gemmiza 3, Sakha 94, Sids 9 and Sids 3 (3064.9, 2842.2, 2552.9, 2534.4, 2416.6 mm, respectively). Most of the Egyptian wheat cultivars showed intermediate values of Avena root length. The same trend of root length of wild oat with different cultivars root diameter results of wild oat were observed with all Egyptian wheat cultivars and there were small differences among cultivars for this trait.

In relation to Potential Allelopathic Activity (PAA), a normal distribution among cultivars for this trait was observed and some cultivars had strong PAA effect and showed the highest percentage, i.e., Sakha 8 (70.2%), Giza 157 (68.5%), Gemmiza 5 (64%), Giza 168 (63.2%), Giza 170 (62.6%) and Giza 160 (61.5%), while some other cultivars like Gemmiza 7, Gemmiza 3, Sakha 94, Sids 9 and Sids 3 showed the lowest percentage of PAA and had weak effects for this trait. The rest of the Egyptian wheat cultivars gave an intermediate percentages for PAA. For more specific effect for each cultivar, Specific Potential Allelopathic Acivity (SPAA) was calculated using PAA values with dry weight of wild oat growing with Egyptian wheat cultivars showed significant effect for each cultivar to suppress Avena weed plants (Table 7). According to the results in this table, Sakha 61, Sakha 8, Giza 160, Giza 157, Giza 168 and Giza 170 revealed the highest values for SPAA to suppress Avena weed plants (1371.9, 1212.4, 1192.7, 1175.7, 1169.7 and 1086.7, respectively). On the other hand, Gemmiza 7, Gemmiza 3, Sids 9 and Sids 3 showed the lowest value for SPAA and seem to be weak for Avena weed suppression (90.6, 197.9, 279.6 and 290.5, respectively).

These results could be summarized as Sakha 8, Sakha 61, Giza 157, Giza 160, Giza 168 and Giza 170 showed the highest values for PAA and SPAA, which accompanied with the smallest root length of Avena species (strong allelopathy effect), which inhibited root growth of Avena species>61.5%, while Gemmiza 7, Gemmiza 3, Sids 9 and Sids 3 showed the lowest values for PAA and SPAA, which accompanied with the longest root length of Avena species (weak allelopathy effect), which inhibited root growth of Avena species<27.3%. Figure (2) shows the allelopathic response for Egyptian wheat cultivars against wild oat. Similar findings have also been reported by (Wu H. *et. al.,* 2000, Wu H. *et. al.,* 2001 and S.P. Zuo *et. al.,* 2006) and the similar trend was found with spring wild oats,. The substantial variations in allelopathic potential in bread wheat cultivars offer a sufficient genetic pool to select novel genotypes from breeding program and to transfer this allelopathic trait into modern cultivars for weed suppression (Niemeyer & Jerez, 1997 and Belz RG., 2007).

The present research study showed similar patterns of PAA distribution and consequently SPAA distribution with intermediate value and the lack of cultivars with high PAA and SPAA indicates that it is necessary to introduce new genes to be able to improve PAA and SPAA of future cultivars (Berthhodsson, 2007, Shen *et. al.,* 2005). In this regard, (Romagni *et. al.,* 2002) and (Reuben and Rodney, 2004) suggested that secondary metabolism in plants will consume a great deal of energy for the defense of the plant, potential allelopathic activity, and nutrient distribution. This research study focused on the possibility to use Competitive Response (CR) for bread wheat cultivars and Competitive Effect (CE) for weed species as indicators to find one or more cultivars with high competitive ability to Avena species in addition to higher potential allelopathic activity and specific potential activity. These findings are in line with studies on rice (Jensen *et. al.,* 2001). The results illustrated that Giza 160, Giza 168 and Sakha 61 could be used to improve the allelopathic potential in breeding program due to its ability to compete weeds and show good response values for competition.

Similarly, it was found that allelopathic potential did not correlate to the root biomass of rice plants (Bach Jensen *et. al.,* 1999). These findings indicate that the competitive trait and allelopathic trait may not be genetically linked and that breeding for wheat cultivars with enhanced competitiveness coupled with allelopathy may be accomplished for weed suppression (Wu *et. al.,* 2000b, Yongqing Ma, 2005, and H. Wu *et. al.,* 1999). It might be useful to screen a large number of wheat accession or advanced lines derived from breeding program or even the commercial cultivars using bioassay (ECAM) in early stage because this bioassay technique separates allelopathy from competition. Studies on allelopathy in crop plants could be important to plant breeders as well as agronomists and in wheat breeding program, allelopathy may play an important role in selecting suitable genotypes.

Table 5. Means of Root Length, Root Diameter, Potential (PAA) for wild oat and Specific Potential Allelopathic Activity (SPAA) in presence of wild oat weed.

Cultivar	Root Length (mm)	Root Diameter (mm)	PAA	SPAA
Sakha 8	988.4	0.72	70.2[a]	1212.4[b]
Sakha 61	1448.5	0.68	56.4	1371.9[a]
Sakha 69	2065.5	0.67	37.9	687.4
Sakha 92	1357.9	0.69	59.1	757.7
Sakha 93	2273.5	0.69	31.5	418.4
Sakha 94	2552.9	0.66	23.2	422.7
Giza 139	1481.4	0.70	55.3	819.7
Giza 144	1522.9	0.72	54.1	731.3
Giza 155	1350	0.69	59.3	982.5
Giza 157	1046.9	0.67	68.5	1175.7[d]
Giza 160	1275.9	0.69	61.5	1192.7[c]
Giza 162	1668.1	0.68	49.9	676.0
Giza 163	1729.0	0.71	47.8	635.6
Giza 164	2379.5	0.72	28.2	343.9
Giza 167	1361.8	0.70	59.0	820.2
Giza 168	1221.2	0.69	63.2	1169.7[e]
Giza 170	1242.6	0.69	62.6	1086.7[f]
Gemmiza 1	1555.4	0.68	53.2	606.8
Gemmiza 3	2842.2	0.67	14.5	197.9[b]
Gemmiza 5	1197.2	0.69	64.0	551.7
Gemmiza 7	3064.9	0.68	8.5	90.6[a]
Gemmiza 9	1921.7	0.68	43.0	507.4
Gemmiza10	2253.7	0.68	32.1	443.2
Sids 1	1542.9	0.74	53.4	694.5
Sids 3	2416.6	0.74	27.3	290.5[d]
Sids 4	1362.4	0.74	59.0	611.5
Sids 6	1436.4	0.67	56.7	566.4
Sids 7	1533.2	0.67	53.7	988.0
Sids 8	2232.8	0.67	32.5	427.0
Sids 9	2534.4	0.67	23.9	279.6[c]
Sids 12	2346.1	0.65	29.5	382.6
Sahel 1	1554.5	0.72	53.2	819.2
Shandwell 1	1821.9	0.72	45.3	637.3
Chenab 70	2055.5	0.69	38.1	528.8
Mexibac 65	2304.4	0.69	30.7	476.1
Tosson	2064.4	0.67	37.7	528.5

** Root Length of Avena specie (control) was 3330.1 mm*

Table 8. Mean square values of analysis of variance among cultivars for Root Length, Root Diameter, Potential (PAA) and Specific Potential Allelopathic Activity (SPAA).

S.O.V	d.f	M.S			
		Root Length	Root Diameter	PAA	SPAA
Replications	3	2132570.2	0.003	225.5	18244.8
Cultivars	35	3015583.2	0.002 **	1016.5 **	394029.4**
Error	105	1787294.2	0.0006	21.2	15121.5

*, ** significant at $P \leq 0.05$ and 0.01, respectively.

REFERENCES

1. Bach Jensen I., B. Courtois, M. Olofsdoner, L. Shen, R.P. Mauleon, Liz. 1999. Locating genes controlling rice allelopathic effects against *Echinochloa crus-galli*, in "Book of abstracts, second world congress on allelopathy-Critical analysis and future prospects". International Allelopathy Society, Thunder Bay, Ontario.
2. Bertholdsson, N.O. 2007. Varietal variation in allelopathic activity in wheat and barley and possibilities to use this in breeding. Allelopathy Journal 19 (1): 1-9.
3. Cochran, W.G. and G.M Cox. 1957. Experimental design. 2nd ed. John Wiley, N.Y., U.S.A.
4. Dilday R.H., W.G. Yan, K.A.K Moldenhauer, K.A. Gravois. 1998. Allelopathic activity in rice for controlling major aquatic weeds. In "Allelopathy in rice". (Ed. M Olofsdotter) pp. 7-26. (IRRI:Los Baros, the Philippines).
5. Duncan, D.B. 1955. Multiple range and multiple F-test. Biometrics, 11: 1-42.
6. EL-Borhamy, H.S., M.A. EL-Maghraby and A.M. Gad Allah. 2008. Genetic behavior of yield and its components in three bread wheat crosses. Egypt. J. Agric. Res., 86 (3).
7. El-Maghraby, M.A., N.O. Bertholdsson, U.M.E. Didon. 2008. Evaluation of the competitive ability of some Egyptian durum wheat cultivars to weeds. Second Field Crops Conference Proceeding, 14-16.
8. Esmail, R.M. 2001. Correlation and path coefficient analysis of some quantitative traits with grain yield in bread wheat (*Triticum aestivum* L.). Bulletin of the National Research Centre (Cairo), 26(3):395-408.
9. Garca del Moral L.F., Y. Rharrabtia, D. Villegasb and C. Royob. 2003. Evaluation of grain yield and its components in durum wheat under Mediterranean conditions. An Ontogenic Approach. Agron. J. 95:266-274.

10. Gomaa A.S.A. 1999. Wheat improvement in Egypt: History and future prospects. Egypt J. Plant Breed. 3: 1-14.
11. Guenzi W.D., T.M. McCalla, F.A. Norstadt. 1967. Presence and persistence of phytotoxic substances in wheat, oat, corn and sorghum residues. Agronomy Journal 59, 163-165.
12. Jensen, L.B., B. Courtois, L.S. Shen, Z. Li, M. Olofsdotter, and R.P. Mauleon. 2001. Locating genes controlling allelopathic effects against barn yard grass in upland rice. Agron. J. 93:21-26
13. Kimber R.W.L. 1967. Phytotoxicity from plant residues. I. The influence of rotted wheat straw on seeding growth. Australian Journal of Agricultural Research 18, 361-374.
14. Larbi, A., A. Mekliche, R. Abed, M. Badis, C. Royo, M.M. Nachit, N. Fonzo, and J.L. Araus. 2000. Effect of water deficit on the yield of two varieties of durum wheat (*Triticum turgidum var. durum*) in a semi-arid region. Proceeding of a seminar, Zaragoza, Spain, 12-14 April 2000. 40: 295-297.
15. Niemyer, H.M., J.M. Jerez. 1997. Chromosomal location go genes for hydroxamic acid accumulation in *Triticum aestivum* L. (wheat) using wheat aneuploids and wheat substitution lines. Heredity 79:10-14.
16. Olofsdotter, M., L.B. Jensen, B. Courtois. 2001. Improving crop competitive ability using allelopathy — an example from rice . Plant Breeding Volume 121, Issue 1, pages 1–9, February 2002.
17. Regina, G. Belz. 2007. Allelopathy in crop/weed interactions — an update. Pest Management Science Volume 63, Issue 4, pages 308–326, April 2007.
18. Regina, G. Belz and H. Karl. 2004. A novel laboratory screening bioassay for crop seedling allelopathy. Journal of Chemical Ecology Volume 30, Number 1, 175-198, DOI:10.1023/B:JOEC. 0000013190.72062.3d
19. Reuben, J.P., B.C. Rodney. 2004. Metabolic engineering of plant secondary metabolism. In: Paul C, Klee H (eds) Handbook of plant biotechnology. Wiley Publishing Inc, Indianapolis, PPn609-627.
20. Romagni, J.G., N.P.D. Nanayakara, R. Rosell, F.E. Dayan. 2002. Ecophysiological roles of selected lichen secondary compounds. In: reigosa MJ, Pedrol N (eds) Allelopathy: from molecules to ecosystems. Sciences publisher, Inc, Plymouth, UK, pp 113-128.

21. **Zuo,** S.P., Y.Q. Ma, and S. Inanaga. 2006. Allelopathy variation in dryland winter wheat (*Triticum aestivum* L.) accessions grown on the Loess Plateau of China for about fifty years. Genetic Resources and Crop Evolution Volume 54, Number 6, 1381-1393, DOI:10.1007/s10722-006-9123-3.
22. SAS Institute. 1990. SAS/STAT user's guide. SAS Inst., Cary, NC.
23. Shen, H, H. Guo, G. Huang. 2005. Allelopathy of different plants on wheat, cucumber and radish seedlings. Ying Yong Sheng Tai Xue Bao. 2005 Apr;16(4):740-3.
24. Snedecore, G.W. and W.G. Cochran. 1967. Statistical methods. 6th ed. Iowa State University Press.
25. Solomon, K.F., M.T. Labuschagne and A.T.P. Bennie. 2003. Responses of Ethiopian durum wheat (*Triticum turgidum var. durum* L.) genotypes to drought stress. South African Journal of Plant and Soil. 20: 2, 54-58.
26. Stephen M. 2007. Allelopathic potential of various plant species on downy brome: Implications for Weed Control in Wheat Production. Agronomy Journal - Article doi: 10.2134/agronj2006.0122Vol. 99 No. 1, p. 127-132 Received: Apr 19, 2006.
27. Wu H., J. Pratley, D. Lemerle, T. Haig. 1999. Crop cultivars with allelopathic capability. Weed Res. 39:171–180.
28. Wu, H., T. Haig, J. Pratley, D. Lemerle, and M. An. 2001. Allelochemicals in Wheat (*Triticum aestivum* L.): Cultivar differences in the exudation of phenolic acids. J. Food Chem. 2001, 49: 3742-3745.
29. Wu, H., J. Pratley, D. Lemerle and T. Haig. 2000. Evaluation of seedling allelopathy in 453 wheat (*Triticum aestivum*) accessions against annual ryegrass (*Lolium rigidum*) by the equal-compartment-agar method. Australian Journal of Agricultural Research 2000 Vol. 51 No. 7 pp. 937-944.
30. Wu, H., J. Pratley, D. Lemerle and T. Haig. 2000. Laboratory screening for allelopathic potential of wheat (*triticum aestivum*) accessions against annual ryegrass (*Lolium rigidum*). Australian Journal of Agricultural Research, 2000, vol. 51, n°2, pp. 259-266 (21 ref.)
31. Wu, H., J. Pratley, D. Lemerle, T. Haig. 2000. Allelopathy in wheat (*Triticum aestivum*). Annals of Applied Biology Volume 139, Issue 1, pages 1–9, August 2001.
32. YONGQING, M.A. 2005. Allelopathic studies of common wheat (*Triticum aestivum* L.). Weed Biology and Management Volume 5, Issue 3, pages 93–104, September 2005.
33. Zhang, X.K., Y. Jiang, W.J. Liang, C.H. Kong. 2004. Research advances in wheat (*Triticum aestivum* L.) allelopathy. China J. Appl. Ecol 15:1967-1972.

١-٩ اتجاهات حديثة لمكافحة الحشائش في القمح بواسطة تفعيل المفرزات المضادة للحشائش

ماهر المغربي[١] ، ياسر مبروك[٢] ، مها جاد الله[١]

١. *قسم بحوث القمح – معهد بحوث المحاصيل الحقلية – مركز البحوث الزراعية – الجيزة – مصر*
٢. *قسم الوراثة – كلية الزراعة – جامعة الاسكندرية – مصر.*

تم تقييم ٣٦ صنف من قمح الخبز الممثلة لمدى واسع من الأصول الوراثية للأقماح المصرية وذلك تحت ظروف منطقة النوبارية فى الموسمين ٢٠٠٧/٢٠٠٨ – ٢٠٠٨/٢٠٠٩ بهدف قياس قدرتها التنافسية للحشائش خاصة حشيشة الزمير (*Avena fatua* L) لانتخاب أفضلها للمقاومة للحشائش. أشار تحليل التباين إلى وجود اختلافات معنوية عالية بين الأصناف لجميع الصفات المدروسة في هذه التجربة. كان تأثير التفاعل بين معاملة الحشائش وأصناف القمح معنويا لكل الصفات تحت الدراسة، وربما يرجع ذلك الى الاستجابة المختلفة للأصناف لمقاومة جذور الزمير تحت ظروف النوبارية. كما أوضحت النتائج أن هناك تأثيرا معنويا لمعاملات الحشائش. وكذلك أوضح التحليل أن مربع انحراف المعاملات للصفات المدروسة معنوي جدا. كما أظهرت النتائج أن الأصناف الأكثر إنتاجية هى : سخا ٦١، جميزة ١٠، سخا٩٤، جميزة٧، جيزة١٦٨ وجيزة ١٥٥، بينما الأصناف طوسون، جيزة١٦٠، جيزة١٦٣، جميزة١ و جيزة١٣٩ كانت ضعيفة الإنتاجية والأصناف الأخرى كان لها سلوك مختلف و تغير ملحوظ بينها تحت الظروف الموصى بها (استخدام مبيد حشائش). من ناحية أخرى، وتحت ظروف الإجهاد (التنافس مع حشيشة الزمير *Avena fatua*) أظهرت الأصناف سخا ٩٢، سدس١، سدس٤، وجميزة ٩ إنتاجية عالية، بينما الأصناف جيزة١٣٩، جيزة١٦٠، جيزة١٦٢، جيزة ١٦٣ وسخا ٩٣ أظهرت إنتاجية منخفضة والأصناف الأخرى كان لها سلوك مختلف تحت ظروف الإجهاد (عدم استخدام مبيد حشائش). أنتجت معظم الأصناف عالية المحصول تحت الظروف الطبيعية وظروف الإجهاد عدد عالي من السنابل/م^2 والتى أوضحت أهمية هذه الصفة لزيادة إنتاجية الحبوب والمكون الرئيسي لمحصول الحبوب. اختلفت الأصناف اختلافا معنويا لكمية الفقد فى محصول الحبوب تبعا لوجود الأعداد المختلفة من حشيشة الزمير/م^2. كان صنف سخا ٦١ هو أعلى الأصناف في محصول الحبوب، بينما الأصناف جيزة١٧٠، سدس٦ وطوسون أظهرت إنتاجية منخفضة من محصول الحبوب وذلك فى وجود ٢٠، ١٠ و ٥ من حشيشة الزمير/م^2. أوضحت الدراسة أيضا أن هناك اختلافات وراثية فى نشاط القدرة التنافسية (allelopathy) فى القمح، وبالتالي توفر مايكفي من الوعاء الجيني لتحسين القدرة التنافسية لأصناف القمح لمقاومة الحشائش. كان التوزيع الطبيعي لنشاط القدرة التنافسية ل ٣٦ صنف قمح دليل على أن نشاط القدرة التنافسية للقمح هى صفة كمية. وقد أظهرت ستة أصناف قدرة تنافسية عالية أعطت أصغر قيم لطول الجذر فى حشيشة الزمير وهذه الأصناف هى: جيزة١٦٠، جيزة١٧٠، جيزة١٦٨، جميزة٥، جيزة١٥٧ و سخا٨ . ويمكن استنتاج أهمية الدراسات على القدرة التنافسية لنباتات المحاصيل لمربي النبات لاستخدامها في برامج التربية، وفى إنتخاب تراكيب وراثية مناسبة لمقاومة الحشائش دون استخدام المبيدات الضارة بالصحة والبيئة.